GMR Genetics and Molecular Research
Online Journal
ISSN:1676-5680

(Co)variance components and genetic parameters for growth traits in Arabi sheep using different animal models

B. Shokrollahi[1] and H. Baneh[2]

[1]Department of Animal Science, School of Agriculture, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran
[2]Young Researchers Club, Sanandaj Branch, Islamic Azad University, Sanandaj, Iran

Corresponding author: B. Shokrollahi
E-mail: Borhansh@Iausdj.ac.ir / Borhansh@yahoo.com

Genet. Mol. Res. 11 (1): 305-314 (2012)
Received October 17, 2011
Accepted November 8, 2011
Published February 8, 2012
DOI http://dx.doi.org/10.4238/2012.February.8.5

ABSTRACT. The objective of the present study was to estimate genetic parameters for body weight at different ages in Arabi sheep using data collected from 1999 to 2009. Investigated traits consisted of birth weight (N = 2776), weaning weight (N = 2002) and weight at six months of age (N = 1885). The data were analyzed using restricted maximum likelihood analysis, by fitting univariate and multivariate animal models. All three weight traits were significantly influenced by birth year, sex and birth type. Age of dam only significantly affected birth weight. Log-likelihood ratio tests were conducted to determine the most suitable model for each growth trait in univariate analyses. Direct and total heritability estimates for birth weight, weaning weight and weight at six months of age (based on the best model) were 0.42 and 0.16 (model 4), 0.38 and 0.13 (model 4) and 0.14 and 0.14 (model 1), respectively. Estimation of maternal heritability for birth weight and weaning weight was 0.22 and 0.18, respectively. Genetic and phenotypic correlations among these traits were positive. Phenotypic correlations among traits were low to moderate. Genetic correlations among traits were positive and higher than the corresponding phenotypic correlations. Weaning weight had a strong and significant correlation with weight at six months of age (0.99). We conclude that selection can be made in animals based on weaning weight instead of the present practice of selection based on weight at six months.

Key words: Arabi sheep; Growth traits; Genetic parameters; Heritability; Genetic correlation

INTRODUCTION

Arabi sheep is one of the native breeds of Iran, where most of these sheep are raised in Khuzestan Province in southeastern of Iran (numbering more than 1.8 million head). In other counties, these sheep are known as Ahwazi or Awasi breed. They are well adapted to hot and humid weather conditions. However, this breed is dual-purpose sheep (meat and wool), but they are mostly kept for their mutton and other productions. To enhance meat production in farm animals, simultaneous improvements in environmental and genetic factors are critical. In addition, providing suitable conditions for expression of genetic potential is necessary, and thus, the enhancement and maximizing of individuals' genetic merit should be achieved. Therefore, next generation parents must be selected among the best current individuals, which have the highest genetic merit. Growth traits particularly pre-weaning in mammalian animals are influenced not just by the animal's own genetic effect, but some other effects such as direct maternal effect and permanent environmental effects. In order to obtain an optimum rate of genetic progress using selection, it is necessary to have high efficiency selection indices and a reliable heritability coefficient for each trait and genetic correlations among traits. Also, estimation of genetic parameters is critical to achieve maximum genetic improvement, taking the best animal selection schemes into account (Baneh et al., 2010).

In recent years, some published reports demonstrated that one of the maternal effects such as additive maternal genetic and permanent environmental effects (or both) could significantly affect growth traits (Abegaz, 2005; Rashidi et al., 2008; Vatankhah and Talebi, 2008; Baneh et al., 2010). Information about genetic parameters and variance components for growth trait in Arabi sheep is inadequate, and thus, this study was performed to estimate genetic and phenotypic parameters for body weight traits in the Arabi sheep breed. Also, estimation of genetic correlations among traits of interest was the other objective of the current research.

MATERIAL AND METHODS

In this research, pedigree information and body weight records of Arabi sheep that were collected during 1999-2009 (11 years) were used. Full pedigree was applied to obtain more completed relationships between animals. Hence, animals with records were traced as much as possible. Traits included: birth weight (BW), weaning weight (WW) and weight at six months of age (SMW). For data edition, 1) outlier observations were made (mean ± three standard deviations), and 2) data of individuals with unknown dam were removed. The dataset included 2776 records for birth of lambs (born from 85 sires and 973 dams), 2002 records for weaning of lambs (born from 72 sires and 820 dams) and 1885 records for lambs at six months of age (born from 72 sires and 786 dams). Significant fixed effects were determined using the GLM procedure by the SAS statistics program. Birth year, lamb's gender and type of lambing had significant effect on all traits. Among the traits, only BW was significantly influenced by age of dam at lambing. In addition, age of lambs at recording time was tested as covariate for WW and SMW and included in the model, because lambs were not at the same age at weighing time (day).

By excluding or including various random effects, six univariate linear animal models were fitted for each trait. Direct additive genetic effect was present in all models and only random effect in Model 1. Models 2 and 3 included maternal permanent environmental effect and maternal additive genetic effect, respectively.

There was an additional effect [direct-maternal genetic covariance ($\sigma_{a,m}$)] in model 4 compared to model 3. Models 5 and 6 included both maternal effects and also without and with covariance between animal effects. The six univariate models which were described, are as follows:

Model 1: $$y = Xb + Z_1a + e$$

Model 2: $$y = Xb + Z_1a + Z_3c + e$$

Model 3: $$y = Xb + Z_1a + Z_2m + e \qquad \sigma_{a,m} = 0$$

Model 4: $$y = Xb + Z_1a + Z_2m + e \qquad \sigma_{a,m} \neq 0$$

Model 5: $$y = Xb + Z_1a + Z_2m + Z_3c + e \qquad \sigma_{a,m} = 0$$

Model 6: $$y = Xb + Z_1a + Z_2m + Z_3c + e \qquad \sigma_{a,m} \neq 0$$

where y is an n×1 vector of observations in each considered trait, and b is a vector of fixed effects, which was found to have a significant effect on related trait. Overall, fixed effects included: lamb's sex (male and female, 2 classes), year of birth (1999 to 2009, 11 classes), birth type (single and twin, 2 classes), and dam age (2-7 years and older ewes, 6 classes).

a, *m*, *c*, and *e* vectors were related to direct additive genetic, maternal additive genetic, maternal permanent environmental effects, and residual effects, respectively. It is assumed that these random effects are normally distributed with a mean of 0 and variances $A\sigma^2_a$, $A\sigma^2_m$, $I_d\sigma^2_c$, and $I_n\sigma^2_e$, respectively. Also, σ^2_a, σ^2_m, σ^2_c, and σ^2_e are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance, and residual variance, respectively. A is the additive numerator relationship matrix that is created using pedigree information. I_d and I_n are identity matrices with dimensions equal to the number of dams and observations, respectively. In addition, X, Z_1, Z_2, and Z_3 are design matrices (0 and 1) that are related to fixed effects, direct additive genetic effects, maternal additive genetic effects, and maternal permanent environmental effects to observations.

Additive direct heritability (h^2), additive maternal heritability (m^2) and maternal permanent environmental effects (c^2) were estimated as ratios of additive direct, additive maternal and permanent environmental maternal variances to phenotypic variance, respectively. The direct-maternal genetic correlation ($r_{a,m}$) was computed as the ratio of the direct-maternal genetic covariance ($\sigma_{a,m}$) to the product of the square roots of σ^2_a and σ^2_m.

Log-likelihood ratio (Log L) tests were performed to determine significant random effects and consequently the most appropriate model for each considered trait.

By inclusion of a random effect in the model, a significant increase in the Log L was seen compared to the reduced model (model without this effect). However, when the difference between the values of Log L was not greater than a critical value of χ^2, the simplest model was considered to be the best model.

Covariances and correlations among traits were estimated using a multi-trait animal model. Hence, the following model was fitted to the data:

$$y_i = X_i b_i + Z_i a_i + e_i$$

where y_i is the vector of observation for trait i, b_i is the vector of fixed effect (includes fixed effects that were found to be significant in least square analysis) for trait i with associated matrix X_i, a_i is the vector of random animal effect for trait i with associated matrix Z_i, and e_i is a vector of random residual effects. X_i and Z_i are incidence matrices for fixed and random effects, respectively.

(Co)variance components and corresponding genetic parameters were estimated using WOMBAT (Meyer, 2007) according to the AI-REML algorithm. Convergence criteria were considered as 1 x 10^{-6}. Total heritability was calculated according to the following equation (Willham, 1972):

$$h_T^2 = \frac{\sigma_a^2 + 0.5\sigma_m^2 + 1.5\sigma_{a,m}}{\sigma_p^2}$$

RESULTS AND DISCUSSION

Descriptive statistics of data used and some pedigree information for each trait are summarized in Table 1. The number of records and phenotypic variation declined with increase in lamb's age (2776 for BW *vs* 1885 for SMW). This diminution in lambs was probably influenced by mortality, lamb culling, selling at older ages, and data editing.

Table 1. Description of data used in the analysis.

Item	Traits		
	BW	WW	SMW
Number of animals (in pedigree)	3331	2548	2430
Base population	582	569	568
Animal with offspring	1058	892	858
Animal without offspring	2273	1565	1572
Number of sire	85	72	72
Number of dams	973	820	786
Dam with records and progeny	433	307	276
Records per dam	2.85	2.44	2.40
Number of records	2776	2002	1885
Mean (kg)	3.95	24.34	30.70
SD (kg)	0.73	4.03	4.69
CV (%)	18.40	16.57	15.28

BW = birth weight; WW = weaning weight; SMW = weight at 6 months of age.

The analysis of variance of environmental effects on the traits studied and least square means for different subclasses of lamb's sex, birth type and age of dam at lambing are given in Table 2. Birth year, sex and type of birth had a significance effect on body weight at birth, weaning and six months of age in this breed. The age of dam had no significant impact on body weight at weaning and six months of age, but BW was significantly affected by the age of dam.

Table 2. Least square means ± SE of the traits studied.

Fixed effects	Traits		
	BW (kg)	WW (kg)	SMW (kg)
Birth year	**	**	**
Sex	**	**	**
Male	3.92 ± 0.02[a]	24.49 ± 0.13[a]	31.41 ± 0.17[a]
Female	3.68 ± 0.02[b]	23.61 ± 0.12[b]	30.12 ± 0.16[b]
Birth type	**	**	**
Single	4.06 ± 0.02[a]	24.95 ± 0.09[a]	31.34 ± 0.12[a]
Twin	3.55 ± 0.03[b]	23.15 ± 0.17[b]	30.19 ± 0.22[b]
Dam's age (years)	**	ns	ns
2	3.74 ± 0.03[bc]	23.94 ± 0.18	30.45 ± 0.24
3	3.73 ± 0.03[c]	23.81 ± 0.19	30.17 ± 0.25
4	3.82 ± 0.03[ab]	24.13 ± 0.19	30.76 ± 0.25
5	3.87 ± 0.03[a]	24.26 ± 0.20	30.95 ± 0.27
6	3.82 ± 0.04[abc]	24.16 ± 0.24	30.88 ± 0.32
7 and more	3.84 ± 0.03[a]	23.99 ± 0.20	30.83 ± 0.26
Regression coefficient on day of birth			

BW = birth weight; WW = weaning weight; SMW = weight at 6 months of age. Means with the same superscript letters for each subclass within a column do not differ (P > 0.05). **P < 0.01. ns = not significant.

Due to climate conditions, feedstuff availability and ewe nutrition, especially during late pregnancy in sheep, it is expected that the birth year affects growth traits. The effect of sex and type of birth can also be caused by differences in the endocrine system, possible loci related to growth on sex chromosome and competition between twins for uterine space, milk consumption and other maternal ability compared to single-born lambs. Single-born lambs were 1802 g heavier than twins, which may be due to intense competition between twins; low milk production by ewe will not provide feed requirement of lambs and consequently they cannot express their potential. It seems that increase in dam age had no effect on milk production and nursing of ewe of this breed. Nevertheless, there is a relationship between age of dam and BW because uterine environment will be better with increasing age.

Also, significant effects of environmental factors on body weight traits have been reported in Ghezel (Baneh et al., 2010), Kermani (Rashidi et al., 2008), Lori-Bakhtiari (Vatankhah and Talebi, 2008), and some other Iranian breeds.

The effect of random factors on birth and WW was similar, so that the addition of maternal permanent environmental effect (model 2), maternal additive genetic effect (model 3) and up to two simultaneous effects of maternal permanent environment and maternal additive genetic effects (model 5) resulted in the same Log L for fitted models for WW, but the addition of the maternal additive genetic effect and its covariance with direct genetic effects (model 4) caused a significant increase in Log L. Since, the Log L of this model compared to full model (model 6) was not significantly different, it can be concluded that the best model for BW and weaning was the fourth model and that these traits were influenced by additive genetic effect and maternal additive genetic effect and their covariance.

Researchers reported that maternal additive genetic effect on weight traits is important and significant, for example, BW in Kermani sheep (Eftekhari Shahroudi et al., 2002), BW in the United Arab Emirates native sheep (Al-Shorepy, 2001) and BW and WW in Merino sheep (Duguma et al., 2002).

If covariance between direct additive genetic effect and maternal genetic effect for SMW were opposed to zero, Log L for fitted models would increase (models 4 and 6), but not significant. In other words, maternal effects (genetic and permanent environmental) did not significantly affect SMW, and thus, the simplest model that includes only the direct additive genetic effects (model 1) was selected as the best model for WW. Baneh et al. (2010) also reported similar results in Ghezel sheep and suggested that WW in Ghezel sheep was only influenced by direct additive genetic effect.

The results of single-trait analysis using different models to estimate additive genetic variance (σ^2_a), maternal permanent environmental variance (σ^2_c), maternal additive genetic variance (σ^2_m), additive and maternal additive genetic covariance ($\sigma_{a,m}$), residual variance (σ^2_e), phenotypic variance (σ^2_p), direct heritability ($h^2_a \pm$ SE), maternal heritability ($h^2_m \pm$ SE), ratio of maternal permanent environmental variance to phenotypic variance ($c^2 \pm$ SE), correlation between direct and maternal additive genetic effects ($r_{a,m} \pm$ SE), and total heritability ($h^2_T \pm$ SE) for different traits are presented in Table 3.

The estimated heritability values for different traits depended on the fitted models. Direct additive genetic variance and heritability estimates for BW and WW, which were estimated using models 1, 2, 3, and 5, had the same values, but the model containing the covariance values suddenly increased. The heritability estimate for BW ranged between 0.17 and 0.42 and for WW ranged between 0.18 and 0.38.

In the best model, direct heritability, maternal heritability, correlation between direct and maternal genetic effects, and total heritability for BW were estimated to be 0.42, 0.22, -0.82, and 0.16, respectively. In the present study, the estimated value for total heritability was similar to that reported by Ligda et al. (2000) in Chios lambs (0.16), but lower than that reported by Maria et al. (1993) in Romanov sheep and Ekiz et al. (2004) in Turkish Merino lambs. Al-Shorepy (2001) reported that the direct heritability, maternal heritability, total heritability, and correlation between direct and maternal genetic effects for BW were 0.42, 0.33, 0.17, and -0.60 in local sheep in United Arab Emirates, respectively. This result agrees with our findings.

In the study by Gizaw et al. (2007), the estimated heritability for BW in Menz sheep was higher (0.46) than that in our study (0.16); the probable reason is ignoring maternal additive genetic effect and its covariance with direct additive genetic effect in their model.

In this study, the heritability estimate for BW was low; the possible reason can be the high phenotypic variance due to environmental factors.

The estimates of maternal permanent environmental effect by models 2, 5 and 6 were 0.05, 0.02 and 0.01, respectively. This is consistent with the findings of Snyman et al. (1995) in Afrino sheep. Also, Matika et al. (2003) suggested that the low effect of maternal permanent environmental effects on BW (0.08) in Sabi sheep is caused by intrauterine environment.

Total heritability estimate for WW in the best model (model 4) was 0.13. This agrees with the estimated values reported by Tosh and Kemp (1994) in Romanov sheep and Vatankhah and Talebi (2008) in Lori-Bakhtiari sheep. In the current study, the level of direct heritability (0.38) was twice as high as maternal heritability, like BW.

Table 3. Different model estimates for growth traits.

Trait	Model	Variance components						Genetic parameters					Log L
		σ^2_a	σ^2_c	σ^2_m	$\sigma_{a,m}$	σ^2_e	σ^2_p	$h^2_a \pm$ SE	$c^2 \pm$ SE	$h^2_m \pm$ SE	$r_{a,m} \pm$ SE	$h^2_T \pm$ SE	
BW	1	0.102426	-	-	-	0.404066	0.506493	0.20 ± 0.04	-	-	-	0.20 ± 0.04	-429.343
	2	0.090587	0.024387	-	-	0.391858	0.506831	0.18 ± 0.04	0.05 ± 0.02	-	-	0.18 ± 0.04	-425.428
	3	0.085242	-	0.02605	-	0.397353	0.508643	0.17 ± 0.04	-	0.05 ± 0.02	-	0.19 ± 0.04	-424.416
	4	0.212848	-	0.111068	-0.125240	0.314723	0.513399	0.42 ± 0.09	-	0.22 ± 0.05	-0.82 ± 0.06	0.16 ± 0.04	-409.913
	5	0.085137	0.011015	0.018258	-	0.393693	0.508103	0.17 ± 0.04	0.02 ± 0.02	0.04 ± 0.03	-	0.19 ± 0.04	-423.985
	6	0.213063	0.061241	0.103858	-0.122514	0.312652	0.513182	0.42 ± 0.09	0.01 ± 0.02	0.20 ± 0.06	-0.82 ± 0.07	0.16 ± 0.04	-409.785
WW	1	2.30587	-	-	-	9.74711	12.053	0.19 ± 0.05	-	-	-	0.19 ± 0.05	-3442.322
	2	2.19738	0.262593	-	-	9.59717	12.0571	0.18 ± 0.05	0.02 ± 0.02	-	-	0.18 ± 0.05	-3441.852
	3	2.18286	-	0.221196	-	9.66805	12.0721	0.18 ± 0.05	-	0.02 ± 0.02	-	0.19 ± 0.05	-3441.930
	4	4.59267	-	2.18815	-2.77072	8.13082	12.1409	0.38 ± 0.09	-	0.18 ± 0.06	-0.87 ± 0.07	0.13 ± 0.05	-3432.241
	5	2.17149	0.186417	0.1119	-	9.59679	12.0666	0.18 ± 0.05	0.02 ± 0.02	0.01 ± 0.02	-	0.18 ± 0.05	-3441.783
	6	4.60500	0.292037	1.89995	-2.68355	8.02038	12.1338	0.38 ± 0.09	0.03 ± 0.02	0.16 ± 0.06	-0.91 ± 0.08	0.13 ± 0.05	-3431.929
SMW	1	2.7946	-	-	-	16.692	19.4865	0.14 ± 0.04	-	-	-	0.14 ± 0.04	-3692.304
	2	2.7946	0.00003	-	-	16.692	19.4865	0.14 ± 0.05	0.00 ± 0.00	-	-	0.14 ± 0.05	-3692.304
	3	2.7946	-	0.00002	-	16.692	19.4865	0.14 ± 0.05	-	0.00 ± 0.00	-	0.14 ± 0.05	-3692.304
	4	3.6417	-	0.2689	-0.73396	16.321	19.4971	0.19 ± 0.07	-	0.02 ± 0.04	-0.74 ± 0.05	0.14 ± 0.05	-3691.748
	5	2.7946	0.00002	0.00002	-	16.692	19.4865	0.14 ± 0.05	0.00 ± 0.00	0.00 ± 0.00	-	0.14 ± 0.05	-3692.304
	6	2.3918	0.1583	0.01253	-0.17309	16.661	19.051	0.13 ± 0.05	0.01 ± 0.02	0.00 ± 0.00	-1	0.11 ± 0.05	-3692.530

BW = birth weight; WW = weaning weight; SMW = weight at 6 months of age; σ^2_a = direct additive genetic variance; σ^2_c = maternal permanent environmental variance; σ^2_m = maternal additive genetic variance; $\sigma_{a,m}$ = additive and maternal additive genetic covariance; σ^2_e = residual variance; σ^2_p = phenotypic variance; h^2_a = direct heritability; c^2 = ratio of maternal permanent environmental variance to phenotypic variance; h^2_m = maternal heritability; $r_{a,m}$ = correlation between direct and maternal additive genetic effects; h^2_T = total heritability; Log L = log likelihood.

Ozcan et al. (2005) estimated total heritability of WW in Turkish Merino sheep to be 0.05, which is lower than the estimates of this study. However, Gizaw et al. (2007) reported much higher levels of heritability for WW in Menz sheep. Possible causes of differences in values obtained in various studies can be due to the different breeds used, different environmental rearing conditions (level and quality of management and nutrition) and different fitted models.

Results published by Rashidi et al. (2008) for WW data, which were analyzed by model 4 in the Kermani breed, were consistent with the findings of the present study; the estimates of these researchers for direct heritability, maternal heritability and correlation between direct and maternal effects were 0.33, 0.21 and -0.40, respectively. Also, the estimates for these parameters in a study by El Fadili et al. (2000) using model 4 (like the best model of this study) for body weight at weaning in the Moroccan Timahdit breed of sheep were 0.50, 0.38 and -1, respectively.

Tosh and Kemp (1994) presented the same values for WW using model 6 in Hampshire sheep. Estimates of direct heritability, maternal heritability and correlation between direct and maternal effects in their study were 0.39, 0.19 and -0.74, respectively.

The estimates of maternal permanent environmental effect in all models were low (≈0.02). Similar estimates in other breeds such as Sabi (Matika et al., 2003), Horro (Abegaz et al., 2007) and Sangsari (Miraei-Ashtiani et al., 2007) have been reported.

Maternal heritability estimates were low in the models without covariance, but in the models with covariance, estimates suddenly increased, which was probably influenced by the negative correlation between direct and maternal genetic effect. Maternal heritability in the best model was 0.18, which is similar to the findings of Larsgard and Olesen (1998) in Norwegian sheep, Abegaz et al. (2007) in Horro sheep and Vatankhah and Talebi (2008) in Lori-Bakhtiari sheep.

These results showed that the estimation of variance components for weight at six months of age in different models differed from body weight at earlier ages. Maternal effects (environmental and genetic) for this trait were estimated to be low and close to zero (or even zero in some models). The possible reason for that is withdrawal of the lamb from its mother just after weaning, resulting in lamb growth at this age (6 months) being almost completely independent of the mother. Results published by Gizaw et al. (2007) in Menz Sheep, and Baneh et al. (2010) in Ghezel sheep showed that maternal effects (maternal additive genetic effect and maternal permanent environmental effect) on SMW were unimportant, and that at later ages, maternal genetic and environmental effect on the incidence of the trait had substantially decreased, where this trait was more influenced by direct additive genetic effect.

In this study, the heritability of SMW was estimated to be 0.14, which agrees with the results reported by Eftekhari-Shahroudi et al. (2002), Abegaz et al. (2007), Vatankhah and Talebi (2008).

Covariance and correlation between direct and maternal genetic effects in both models 4 and 6 were negative for all traits and ranged between -0.74 and -1 (-0.82), respectively (Table 4). Some researchers estimated a negative correlation for BW (Robison, 1981; Meyer, 1992; Van Wyk et al., 1993; Tosh and Kemp, 1994; Ligda et al., 2000). However, in some breeds, the estimates were positive (Nasholm and Danell, 1996; Yazdi et al., 1997).

Table 4. Estimation of genetic, environmental and phenotypic correlations between traits.

Traits		σ_a	σ_e	σ_p	r_a	r_e	r_p
BW	WW	0.162638	-0.03989	0.122746	0.36 ± 0.15	-0.02 ± 0.02	0.05 ± 0.02
BW	SMW	0.211484	0.072313	0.283797	0.41 ± 0.16	0.03 ± 0.02	0.10 ± 0.02
WW	SMW	2.2594	6.03735	8.2967	0.99 ± 0.08	0.47 ± 0.03	0.54 ± 0.02

BW = birth weight; WW = weaning weight; SMW = weight at 6 months of age; σ_a = additive genetic covariance between traits 1 and 2; σ_e = environmental covariance between traits 1 and 2; σ_p = phenotypic covariance between traits 1 and 2; r_a = additive genetic correlation between traits 1 and 2; r_e = environmental correlation between traits 1 and 2; r_p = phenotypic correlation between traits 1 and 2.

Maria et al. (1993) reported that genetic correlations between direct and maternal genetic effects for BW were 0.99 in Romanov sheep. They mentioned that the negative estimate for this parameter was due to the small number of data in their study, pedigree structure, correlation of environmental effects, and natural selection.

Correlation between BW and WW in the present study (0.36) was consistent with the results of Vaez-Torshizi et al. (1992), Eftekhari-Shahroudi et al. (2002), Neser et al. (2001), and Baneh et al. (2010). The estimated genetic correlation between BW and SMW (0.41) was close to the values reported by Miraei-Ashtiani et al. (2007) in Sangsari sheep and Baneh et al. (2010) in Ghezel sheep, but lower than the values reported by Gizaw et al. (2007) in Menz sheep.

In numerous studies, genetic correlations between WW and SMW were found to be higher than the correlation between traits in later ages, which was probably caused by a similar pattern of gene expression affecting growth at 3 and 6 months of age.

In present research, the correlation between WW and SMW (0.99) (Table 4) was consistent with the results of Gizaw et al. (2007) and Miraei-Ashtiani et al. (2007). High positive genetic correlation between WW and SMW demonstrates that there is stronger correlation between them than their correlation with BW. Also, selection based on WW may help to improve SMW.

In conclusion, genetic and phenotypic correlations were positive in all cases. Similar genes or genes with pleiotropy functions probably affect these traits. Hence, we expect that if selection is carried out for each of these traits at every stage of life, it will be effective for weight gain in later ages and can lead to genetic improvement in body weight at later ages. The phenotypic correlation for all traits was lower than genetic correlation, which is consistent with the majority of reported results. This is probably due to the influence of environmental factors and environmental correlation. Therefore, selection based on genetic correlation is recommended.

ACKNOWLEDGMENTS

Research supported by the Islamic Azad University, Sanandaj Branch. We thank the research and technology deputy of the university (Dr. Adel Fatemi) for his valuable help.

REFERENCES

Abegaz S, Van-Wyk J and Olivier J (2007). Model comparisons and genetic and environmental parameter estimates of growth and the Kleiber ratio in Horro sheep. *S. Afr. J. Anim. Sci.* 35: 30-40.

Al-Shorepy S (2001). Estimates of genetic parameters for direct and maternal effects on BW of local sheep in United Arab Emirates. *Small Ruminant Res.* 39: 219-224.

Baneh H, Hafezian SH, Rashidi A, Gholizadeh M, et al. (2010). Estimation of genetic parameters of body weight traits in Ghezel sheep. *Asian-Aust. J. Anim. Sci.* 23: 149-153.

Duguma G, Schoeman S, Cloete S and Jordaan G (2002). Genetic parameter estimates of early growth traits in the Tygerhoek Merino flock. *S. Afr. J. Anim. Sci.* 32: 66-75.

Eftekhari-Shahroudi E, Bahrini MR, Ven Doulk D and Danesh Mesgaran M (2002). The factor affecting some economical traits in Kermani sheep. *Iran. J. Agr. Sci.* 33: 395-402.

Ekiz B, Ozcan M and Yilmaz A (2004). Estimates of genetic parameters for direct and maternal effects with six different models on birth and weaning weight of Turkish Merino lambs. *Turk. J. Vet. Anim. Sci.* 28: 383-389.

El Fadili M, Michaux C, Detilleux J and Leroy PL (2000). Genetic parameters for growth traits of the Moroccan Timahdit breed of sheep. *Small Ruminant Res.* 37: 203-208.

Gizaw S, Lemma S, Komen H and Van Arendonk JAM (2007). Estimates of genetic parameters and genetic trends for live weight and fleece traits in Menz sheep. *Small Ruminant Res.* 70: 145-153.

Larsgard AG and Olesen I (1998). Genetic parameters for direct and maternal effects on weights and ultrasonic muscle and fat depth of lambs. *Livest. Prod. Sci.* 55: 273-278.

Ligda C, Gabriilidis G, Papadopoulos T and Georgoudis A (2000). Investigation of direct and maternal genetic effects on birth and weaning weight of Chios lambs. *Livest. Prod. Sci.* 67: 75-80.

Maria GA, Boldman KG and Van Vleck LD (1993). Estimates of variances due to direct and maternal effects for growth traits of Romanov sheep. *J. Anim. Sci.* 71: 845-849.

Matika O, Van Wyk JB, Erasmus GJ and Baker RL (2003). Genetic parameter estimates in Sabi sheep. *Livest. Prod. Sci.* 79: 17-28.

Meyer K (1992). Variance components due to direct and maternal effects for growth traits of Australian beef cattle. *Livest. Prod. Sci.* 31: 179-204.

Meyer K (2007). WOMBAT: a tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). *J. Zhejiang Univ. Sci. B.* 8: 815-821.

Miraei-Ashtiani SR, Seyedalian SAR and Moradi Shahrbabak M (2007). Variance components and heritabilities for body weight traits in Sangsari sheep, using univariate and multivariate animal models. *Small Ruminant Res.* 73: 109-114.

Nasholm A and Danell O (1996). Genetic relationships of lamb weight, maternal ability, and mature ewe weight in Swedish finewool sheep. *J. Anim. Sci.* 74: 329-339.

Neser FW, Erasmus GJ and van Wyk JB (2001). Genetic parameter estimates for pre-weaning weight traits in Dorper sheep. *Small Ruminant Res.* 40: 197-202.

Ozcan M, Ekiz B, Yilmaz A and Ceyhan A (2005). Genetic parameter estimates for lamb growth traits and greasy fleece weight at first shearing in Turkish Merino sheep. *Small Ruminant Res.* 56: 215-222.

Rashidi A, Mokhtari MS, Jahanshahi AS and Abadi MMR (2008). Genetic parameter estimates of pre-weaning growth traits in Kermani sheep. *Small Ruminant Res.* 74: 165-171.

Robison O (1981). The influence of maternal effects on the efficiency of selection: a review. *Livest. Prod. Sci.* 8: 121-137.

Snyman MA, Erasmus GJ, Van Wyk JB and Olivier JJ (1995). Direct and maternal (co)variance components and heritability estimates for body weight at different ages and fleece traits in Afrino sheep. *Livest. Prod. Sci.* 44: 229-235.

Tosh JJ and Kemp RA (1994). Estimation of variance components for lamb weights in three sheep populations. *J. Anim. Sci.* 72: 1184-1190.

Vaez-Torshizi R, Emam Jomeh N, Nik Khah A and Hejazi M (1992). A study of pre weaning traits in a Baluchi sheep Flock. *Iran. J. Agr. Sci.* 23: 33-42.

Van Wyk JB, Erasmus GJ and Kostantinov KV (1993). Variance components and heritability estimates of early growth traits in the Elsenburg Dormer sheep stud. *S. Afr. J. Anim. Sci.* 23: 72-76.

Vatankhah M and Talebi MA (2008). Heritability estimates and correlations between production and reproductive traits in Lori-Bakhtiari sheep in Iran. *S. Afr. J. Anim. Sci.* 38: 110-118.

Willham RL (1972). The role of maternal effects in animal breeding: III. Biometrical aspects of maternal effects in animals. *J. Anim. Sci.* 35: 1288.

Yazdi M, Engström G, Näsholm A, Johansson K, et al. (1997). Genetic parameters for lamb weight at different ages and wool production in Baluchi sheep. *Anim. Sci.* 65: 247-255.

